



# SatNav News

FAA Satellite Navigation Product Teams

## WAAS Service Expands In Alaska

Since commissioning in July 2003, WAAS has been providing valuable benefits to aviation users. Pilots use WAAS for improved situational awareness and also to fly new WAAS-enabled localizer performance with vertical guidance (LPV) approach procedures. However, until very recently, WAAS service was very limited in Alaska. WAAS was available only in the southeastern portion of Alaska and, even there, only with limited availability. At the beginning of August, this changed and WAAS was expanded throughout Alaska.

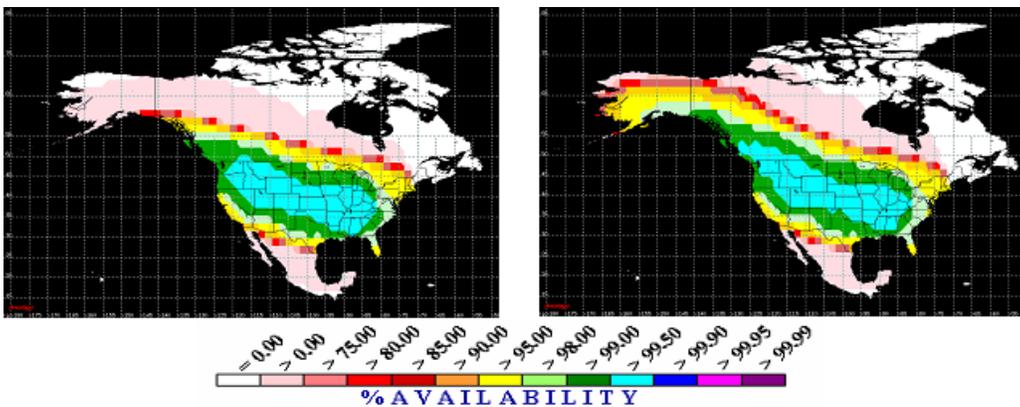
This expansion of service was made possible by the installation and integration of four new WAAS wide-area reference stations (WRS) into the WAAS network. On August 4<sup>th</sup>, these four new stations - located in Barrow, Bethel, Fairbanks, and Kotzebue - came on line. Each new station brought with it contributions to the total gain in WAAS coverage. This accomplishment was the result of several years of work to identify and approve the most beneficial WRS locations, complete site surveys, install equipment, code and test corresponding software upgrades, and conduct test and integration activities. With these activities now complete, the expanded service is operational.

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Availability Model of WAAS Service Supporting LPV Approach Capability Prior to the Integration of Additional Alaska Stations

Availability Model of WAAS Service Supporting LPV Approach Capability After the Integration of Additional Alaska Stations



WAAS Coverage Availability Plots Produced by MITRE Corp. These simulations of WAAS service availability are based on a set of pre-determined assumptions. Actual performance may vary. (All Rights Reserved)

The differences in WAAS service coverage are significant. In Southeast Alaska, WAAS availability was at 75% or less for those aviation operations requiring vertical guidance. Now, WAAS models predict service to be available, on average, 98% of the time. Even more significant is the extension of WAAS service to the remainder of Alaska. In the

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WAAS Wide-Area Reference Stations (WRS) Locations - The new Alaskan WRSs complement the original twenty-five WRSs that have been in operation since WAAS commissioning in 2003. Nine more WRSs, located in Canada and Mexico, will be incorporated into the WAAS in the years to come.

past, WAAS had been extremely limited in its ability to support aviation applications. Now, WAAS service is available throughout most of the state 95% of the time or better.

This expanded service is particularly beneficial in Alaska where air transportation is often the only practical mode of transportation to and from many remote parts of the state. Mountains and vast stretches of remote terrain make it impractical to install and maintain sufficient ground-based navigation equipment to effectively serve the entire state. Satellite navigation systems, such as the Global Positioning System (GPS) and WAAS, offer the ability to serve areas of Alaska where traditional navigation systems are simply not available. Initially, GPS was adopted to overcome the challenges posed by the terrain and vastness of Alaska, but GPS

alone still has its limitations. WAAS provides higher availability for all aviation operations than provided by GPS alone. WAAS also improves the accuracy, including the reliable vertical guidance, required to fly LPV approaches. Three airports in Alaska are currently awaiting flight check for LPV procedures (Anchorage International Airport - PANC, Emmonak Airport – PAEM, and Homer Airport – PAHO).

The extension of WAAS service into Alaska is the first step in broadening WAAS coverage. In years to come, WAAS service will also be expanded to Canada and Mexico. Installations of WAAS stations in both Canada and Mexico have recently been completed and are scheduled to begin coming on-line starting in September 2007.

- Mary Ann Davis, FAA GPS TAC



## New WAAS GEO Ready To Go

In November, the FAA's Wide Area Augmentation System (WAAS) achieved a new milestone – the addition of a new WAAS navigation transponder onboard a geostationary satellite (GEO). This new GEO service is the first of two GEOs to be integrated into WAAS service as part of the Ground Communications and Control Segment (GCCS) contract with Lockheed Martin.

The new GEO, PanAmSat (PAS) Galaxy XV, is located above the equator over the Pacific Ocean at 133° W longitude. From this orbital position, the PAS GEO is able to broadcast the WAAS signal across the entire U.S. As such, this new GEO service restores WAAS aviation service to New England. Portions of New England were adversely affected earlier this year when the Inmarsat AOR-W GEO, the satellite which

mean to the users? It means that users in the Northeastern U.S. have a return of WAAS aviation service. It also means that users across the U.S. have an increase in WAAS aviation service availability.

With the PAS GEO service operational within the WAAS, the FAA now turns its focus to the testing and introduction of ranging service for the PAS GEO (to be available in late spring 2007) and the introduction of service on the second GCCS GEO, Telesat (also to be introduced in late spring 2007).

- Ed Sigler, FAA GPS TAC

## WAAS Avionics Update

The race to provide WAAS avionics to the aviation community is proving to be more of a marathon than a sprint. More

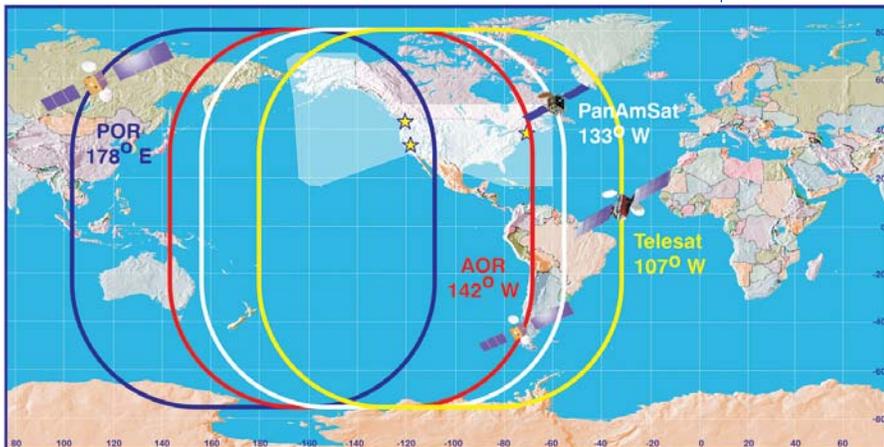
than three years since the WAAS system was commissioned as a primary means of navigation, few options are on the shelf today, but manufacturers are working to change that.

Leading the pack in the general aviation (GA) market is Garmin International Inc., with the GNS 480 which had been the only certified receiver that could be used to fly a localizer performance with vertical guidance (LPV) approach. In the homestretch, Garmin continued in its efforts and recently announced the long awaited WAAS LPV upgrade to the GNS 430 and GNS 530 series of panel mount receivers. Garmin recently crossed the finish line

with its G1000 by receiving approval for its integrated avionics system, with WAAS LPV capability, as part of the original equipment of the newly certified Cessna Mustang.

Garmin's competition is limited. Chelton Flight Systems, who has partnered with FreeFlight Systems to produce an Electronic Flight Instrument System (EFIS) with a GPS/WAAS sensor certified for enroute operations will provide LPV certification for the EFIS when a compatible GPS/WAAS receiver is available to them. Honeywell has hinted that they also plan to introduce WAAS to its Bendix/King line of avionics. With sales of more than 4,000 GNS 480 WAAS receivers, and more than 17,000 receivers signed up for the GNS 430 and GNS 530 upgrade, Garmin has set the pace for WAAS avionics in the GA market.

In the past, avionics manufacturers have been cautious about investing in WAAS for the business and regional aviation market due to high development costs, a smaller market, and a customer base that uses airports where Instrument



WAAS GEO Footprints – POR, AOR-W, PanAmSat (November 2006) and Telesat (Spring 2007)

hosts one of the current operational WAAS navigation transponders, moved west from its position above the Atlantic Ocean to a new position above the Pacific Ocean.

The PAS GEO, launched in October 2005, has been undergoing a series of tests and integration with WAAS ground components. Operational requirements and tight safety tolerances dictate an extended integration and test phase for the new GEO services. One aspect of the WAAS signal is that it is 'GPS-like', meaning it can be used as a ranging source similar to GPS satellite signals. However, testing and satisfying the strict ranging requirements involve GEO system tuning and testing conducted over weeks of time. In order to bring the PAS GEO into the WAAS as soon as possible, in part to return WAAS aviation service to New England sooner, the decision was made to initially forego ranging service verification on the PAS GEO. What does this



Landing Systems (ILS) are the rule rather than the exception. However, as the market begins to realize the benefits of WAAS relating to LPV approaches, Required Navigation Performance (RNP), and flight planning, all realized as the FAA continues its transition toward the use of satellite navigation; avionics manufacturers are taking notice and development efforts are under way.

Universal Avionics is well off the starting block with their WAAS avionics developmental efforts. They report impressive results flying with a WAAS equipped 'red-labeled' UNS-1 in their corporate aircraft, and enjoy its seamless international Global Navigation Satellite System (GNSS) capabilities. Its market entry includes a dual flight management system (FMS) solution expected to be certified by the second quarter of 2007.

Rockwell Collins and CMC are currently developing FMS integrated WAAS avionics under a contract with the FAA to equip their fleet and promote general adoption in the market. Rockwell Collins will equip Learjet and Challenger 604 flight inspection aircraft with its WAAS GNLU-955 multimode receivers. Completion of this effort is expected February 2007. Rockwell Collins is also under contract with the FAA to develop a Technical Service Order (TSO) certified GPS-4000S receiver for WAAS-enabled enroute, terminal, and LPV approach operations, as well as a supplemental type certificate (STC) for Bombardier CRJ aircraft. Lastly, the FAA Technical Center (FAATC) has a contract with CMC Electronics to integrate a WAAS-enabled sensor into the Honeywell Primus-2000 FMS unit in the FAATC Global-5000 aircraft. In addition to equipping FAA aircraft, these efforts are expected to springboard development and certification of related FMS systems and airframes.

While the industry initially took a wait-and-see approach to development, the improving WAAS coverage, LPV procedure production, and resulting customer demand—ranging from GA to the airlines—has forced avionics manufacturers to tighten their laces and join the race.

- Tom Salat and Brad Zeigler, FAA GPS TAC

*(This article covers a sample of work currently underway in the WAAS avionics market. If you or your company is involved in any related initiatives not included here, please e-mail Tom Salat (thomas.ctr.salat@faa.gov) and we will incorporate this information in future updates on avionics activities. Please include "WAAS Avionics Initiative" in the subject line of the e-mail.)*

## LPV Watch

<b>Total LPVs Published To Date</b>	<b>640</b>
Located at Part 139 Airports	394
Located at Non-Part 139 Airports	246
To Runways Also Served by an Instrument Landing System (ILS)	304
To Runways Not Served by ILS	336
To Airports Not Served by ILS	162
<b>Total Number of Airports with LPVs</b>	<b>377</b>
Part 139 Airports	200
Non-Part 139 Airports	177
(LPVs to Non-Part 139 Airports w/No ILS)	162

Every 56 days, new procedures are published as a part of the Terminal Procedures Publication (TPP) cycle. On occasion, procedures may be published during the interim months as a part of an Operations Change Notice (OCN). As of the last TPP (November 23, 2006), there were 640 published localizer performance with vertical (LPV) approaches. The table above shows the types of airports and runways currently served. There are now 377 airports that have LPVs and that number is growing every 56 days. A listing of current airports served by LPVs (including information on runways served, corresponding decision altitudes, WAAS channel numbers, and other information) can be found on our website. To access this information, go to <http://gps.faa.gov> and select the GPS/WAAS Approaches button from the front page.



## Integrity Design Documents Completed for LAAS

The Local Area Augmentation System (LAAS) program has achieved another milestone bringing the implementation of satellite navigation for Category (CAT) I operations closer to reality. The LAAS uses ground stations and a local area broadcast to augment the accuracy of the Global Positioning System (GPS) for use by commercial aviation in terminal operations. In September 2004, the FAA Administrator directed the descoping of a Honeywell production contract for 60 CAT I LAAS ground stations to focus the program's resources on research solutions to key integrity risk areas. This research has now culminated in the validation of the algorithm design of 11 integrity monitors that are necessary to perform CAT I landings.



The requirement for a ground-based augmentation system, or GBAS (the international term used for LAAS), to perform instrument approaches down to 200 feet is very demanding. The requirement states that a ground station shall not transmit hazardous misleading information to the aircraft GPS-derived position no more than one in 10 million landings. To meet this requirement, the LAAS ground station employs 11 monitors that check the information used to correct ranging information from the GPS satellites. These monitors check atmospheric delays associated with the troposphere and ionosphere, biases associated with ground station antennas and receivers, daily and seasonal environmental changes, and satellite malfunctions.



Before this equipment can be used operationally, it must go through two certification processes. The first process is to approve, or certify, the design of the system for aviation use. The second approval is the equipment installation for each particular location where it will be used, also known as facility approval. As a part of the FAA/ASA MOC, the FAA will support the system approval. ASA will then approve the installation of the equipment, or facility certification, for operation of this equipment in the airspace at Sydney.

Each monitor requires a software design document called an Algorithm Description Document (ADD) that consists of four main sections. The first section of each document describes the threat that the monitor is trying to mitigate. The second section describes all the top level and derived requirements that the monitor must meet. The third section details algorithm equations that need to be coded and the fourth section contains the analysis that validates the algorithm equations.

All the ADDs have now been completed and have been presented to a LAAS Integrity Panel for approval. Once approved, Honeywell will code the algorithms and install them in a Honeywell-developed LAAS prototype at Memphis International Airport. Using this prototype, flight tests will be conducted along with stability testing to verify that the algorithms work in an operational environment. Testing will be difficult because some of the conditions that the monitors are to detect are rare events. For example, storms in the ionosphere that can cause errors may occur only once every 4 years.

The next phase of the program is to support full implementation of the monitors in a certifiable system being developed by Honeywell through a contract with Airservices Australia (ASA). In February 2006, FAA and ASA signed a memorandum of cooperation (MOC) to support approval of a Standards and Recommended Practices (SARPs)-compliant GBAS, based on the FAA-approved Honeywell design.

FedEx also plans to upgrade the Honeywell LAAS installed at Memphis. Memphis is a major hub for FedEx and the increased accuracy of LAAS out to 60 miles can reduce operation delays in inclement weather. In order for the algorithms to work on the Memphis equipment, the current processors and antennas will need to be upgraded and certified to DO-254 hardware standards. These modifications will bring the Memphis equipment up to the same design that will be approved in Australia as a part of the FAA/ASA MOC. As a result, after the system at Memphis receives the required upgrades, it will only need to go through the facility certification process. The FAA will approve the facility at Memphis. If everything goes according to plan, the Memphis LAAS can be operational for CAT I service late in 2008.

In summary, the integrity risks and design problems associated with using LAAS for all-weather CAT I instrument approaches down to 200 feet have been resolved. The mitigation of these risks and the design of the algorithms to support this service have been documented in 11 algorithm description documents. The next step is to certify these algorithms to DO-178 software standards and to certify the hardware they interface with to DO-254 standards. This certification program is being completed cooperatively between the FAA and ASA. Plans include an operational system at Sydney International Airport with one to follow shortly thereafter at Memphis International Airport. After experience is gained with these systems in CAT I service, a determination will be made as to what improvements are necessary to support CAT II/III service. CAT II/III service supports landings in all weather conditions including times when visibility reaches zero.

- Rich Lay FAA GPS TAC

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